REMARKS

Claims 1-26 are all the claims currently pending in the present application. By this Amendment, claim 1 is amended to recite the features of allowable claim 6, and claim 6 is canceled; thus, Applicant submits that claim 1 and all claims dependent from claim 1 are now allowable. Claim 8 is amended to be in independent form, including all features of limitations of claim 1 as previously presented; claims 9, 20, and 25 are amended only to correct their dependencies; and new claims 27-28 are added. The amendments introduce no new matter.

It is noted that the claim amendments, if any, are made only to assure grammatical and idiomatic English and improved form under United States practice, and are not made to distinguish the invention over the prior art or narrow the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

Applicant appreciates the Examiner's indication that claim 6 would be allowable if rewritten in independent form. However, for at least the reasons discussed below, Applicant submits that all claims herein are patentable.

The Examiner has alleged that the features of claim 25 are disclosed in the prior art. However, claim 25 depends from allowable claim 6. Therefore, Applicant presumes that the Examiner mistook claim 25 as depending only from rejected claims, and that the proper status of claim 25 is allowable.

Claims 1-5, 7-9, 12-21, and 23-26 stand rejected under 35 U.S.C. §103(a) over Ma (US 6,891,865) in view of Chin, et al. (US 6,643,421) and Po (US 4,852,117). Claims 10-12

and 22 stand rejected under 35 U.S.C. §103(a) over Ma in view of Chin and Po, and further in view of Margalit, et al. (US 6,668,006). These rejections are respectfully traversed in the following discussion.

THE CLAIMED INVENTION

The claimed invention, as exemplarily defined by independent claim 8, is directed to a tunable laser. The tunable laser includes a multiple ring resonator, an LD-side waveguide, a reflection-side waveguide, a single board, a reflection film, a laser diode chip, and a tuning device.

The multiple ring resonator includes a plurality of ring resonators. The ring resonators are constituted with ring-type waveguides. The ring-type waveguides have optical path lengths different from each other. The ring-type waveguides are coupled through an optical-coupling device.

The LD-side waveguide has one end connected to one of the plurality of ring resonators through an optical-coupling device.

The reflection-side waveguide has one end connected to a different one of the plurality of ring resonators through an optical-coupling device.

The ring resonator, the LD-side waveguide and the reflection-side waveguide are formed on the single board.

The reflection film is provided to the other end of the reflection-side waveguide. The reflection film comprises a high-reflection film which is capable of sufficiently reflecting laser light without regard to a wavelength of a transmission peak of the laser light.

The laser diode chip has a low reflection film formed on one of two opposing

emission end faces, which is optically coupled to the LD-side waveguide through the low reflection film.

The tuning device changes a resonance wavelength of only the multiple ring resonator. <u>The tuning device changes refractive indexes of the ring-type waveguides of the ring resonators for changing the resonance wavelength</u>.

In the laser element where the tuning mechanism is provided outside the laser element, mode jump is easily generated by the oscillation. Thus, it requires a large-scaled oscillation-resistant mechanism for avoiding the mode jump, which results in large-scaled module and increased price.

The present invention, on the other hand, overcomes obstacles for practical use, and provides a highly reliable, high-performance, and low-price tunable laser. With the present invention, the waveguide refractive index can be changed by the thermooptic effect. The thermooptic effect is a phenomenon in which the refractive index of a material is increased by heat, which can normally be observed in any kinds of materials. In other words, it is possible to change the resonance wavelength of the multiple ring resonator by utilizing the temperature properties of a plurality of ring resonators. The tuning device may be either type that heats or cools the ring resonator. As described above, the present invention constitutes the multiple ring resonator through connecting a plurality of ring resonators with slightly different circumferences in series, and utilizes the Vernier effect generated thereby.

With the tunable laser according to the present invention, the laser light of an <u>extremely wide range of wavelengths</u> can be obtained by mounting the LD chip on the board where the multiple ring resonator is formed and by <u>changing the resonance wavelength through control of the temperature of the multiple ring resonator</u>. Furthermore, it is highly

reliable since there is no injection of electric current to the semiconductor laser and no mechanical movable member is used therein. Moreover, it can be formed by simply mounting the LD chip on the board, so that it can be manufactured easily at low cost.

The use of the laser structure according to the present invention achieves the tuning action over a wide range of wavelengths that cannot be achieved with a regular DFB-LD, through a simple structure using no external mirror that has been used conventionally. Furthermore, there is no movable part provided therein, unlike the regular tunable laser of the external mirror type. Thus, high oscillation impact characteristic can be achieved in addition to achieving high reliability. Moreover, the change in the property over time is extremely smaller compared to the system that injects electric current to the semiconductor waveguide, because the refractive indexes of the ring-type waveguides of the ring resonator are changed for tuning the wavelengths. A tunable laser according to the present invention is thus superior to the conventional tunable laser in many respects, and it can be manufactured at a low cost.

THE PRIOR ART REJECTIONS

Applicant maintains the arguments of the amendments of December 16, 2008, and June 9, 2009. Some of those arguments may be repeated below for the convenience of the Examiner.

The Ma Reference

The Examiner alleges that certain features of the claims are disclosed by Ma. Applicant submits that there are features of the claims as recited which are neither taught nor

suggested by Ma.

Claims 1-5, 7-9, 12-21, and 23-26 stand rejected over Ma (US 6,891,865) in view of Chin and Po. Claims 10-12 and 22 stand rejected over Ma in view of Chin and Po, and further in view of Margalit. Claim 1 is amended hereby to recite the features of allowable claim 6; thus, Applicant submits that claim 1 and all claims dependent from claim 1 are now allowable.

With further regard to claims 8-9, 20-21, 23-24, and 26-28, Applicant submits that Ma, both alone and in combination with Chin and Po, fails to disclose or suggest at least "A tunable laser, comprising: a multiple ring resonator in which a plurality of ring resonators, which are constituted with ring-type waveguides having optical path lengths different from each other, are coupled through an optical-coupling device; an LD-side waveguide having a first end connected to one of the plurality of ring resonators through an optical-coupling device; a reflection-side waveguide having a first end connected to other one of the plurality of ring resonators through an optical-coupling device; a single board on which the ring resonator, the LD-side waveguide and the reflection-side waveguide are formed; a reflection film provided to a second end of the reflection-side waveguide, wherein said reflection film comprises a high-reflection film capable of reflecting laser light without regard to a wavelength of a transmission peak of said laser light; a laser diode chip having a low reflection film formed on one of two opposing emission end faces, which is optically coupled to the LD-side waveguide through the low reflection film; and a tuning device for changing a resonance wavelength of only the multiple ring resonator, wherein the tuning device changes refractive indexes of the ring-type waveguides of the ring resonators for changing the resonance wavelength," as recited in independent claim 8.

The Examiner alleges that, "*In re claims 8, 9, 20, 21, & 26, Ma discloses wherein the tuning device changes refractive indexes of the ring-type waveguides of the ring resonators for changing the resonance wavelength (col. 3 lines 16-19)..*" Office Action, p. 5.

However, the cited reference discloses only, "*The resonance wavelength of the optical resonators may be adjusted or tuned by applying voltage or injecting current to the resonator.*" Ma, col. 3, lines 16-19.

Applicant submits that both applying voltage and injecting current, as taught by Ma, fail to disclose or suggest at least changing a refractive index of the ring-type resonators, as recited in the claims.

Ma discloses electrically adjusting the refractive index of the semiconductor, not heat adjustment of the ring-type waveguides. "*There are basically two main alternative methods of electrically changing the refractive index of a semiconductor, of which the optical resonator of the present invention is composed, which results in a change in resonance frequency of the resonator. The first method utilizes the electro-optic effects that result when a voltage is applied to the resonator. The second method utilizes the carrier effects resulting from injecting current into the resonator.*" Ma, col. 15, lines 4-11.

Thus, Ma fails to disclose or suggest at least this feature of the claims.

With further regard to claims 9, 20-21, and 26-28, the refractive properties and resonant wavelength of each of the ring-type waveguides are adjusted by utilizing temperature properties. That is, carrier injection and mechanical tuning are avoided.

The Examiner alleges only, ""*In re claims 8, 9, 20, 21, & 26, Ma discloses wherein the tuning device changes refractive indexes of the ring-type waveguides of the ring resonators for changing the resonance wavelength (col. 3 lines 16-19).*" Office Action, p. 5.

The cited passage of Ma, reproduced above, fails to disclose or suggest adjusting refractive indexes of the ring-type waveguides. Instead, Ma discloses only applying voltage and injecting current, as discussed above. Thus, Ma fails to disclose or suggest adjusting the refractive properties of the ring-type waveguides.

Further, claims 20-21 and 26 recite that said adjustment is accomplished only by the recited means. Thus, references that rely on other means, such as applying voltage or injecting current, inherently fail to disclose or suggest adjusting using only the recited temperature means.

With further regard to claims 23-24, the Examiner alleges, "*In re claims 23 & 24, Ma discloses wherein film-like heaters (electrodes 128i- 128iii) are provided as the tuning device (col. 14 lines 55-57).*" Office Action, p. 7.

With regard to claims 23 and 24, the temperature is adjusted by a simple means such as film-like heaters, which can be formed directly on the board, thus further reducing complexity and cost.

The cited reference discloses only, "*Electrode contacts 128_i, 128_{ii}, and 128_{iii}, are shown positioned on top of the resonators 122_i, 122_{ii}, and 122_{iii}.*" Ma, col. 14, lines 55-57.

However, Ma fails to disclose or suggest film-like heaters which can be formed directly on the board. The Examiner fails to cite any passage of Ma which discloses or suggests that the electrode contacts comprise film-like heaters.

Thus, Ma fails to disclose or suggest at least these features of the claims.

Therefore, Applicant respectfully requests the Examiner reconsider and withdraw the rejection of claims 1-5 and 7-26 over Ma in view of Chin and Po, or Ma in view of Chin, Po, and Margalit.

CONCLUSION

In view of the foregoing, Applicant submits that claims 1-28, all the claims pending in the application, are patentably distinct over the prior art of record and are allowable, and that the application is in condition for allowance. Such action would be appreciated.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned attorney at the local telephone number listed below to discuss any other changes deemed necessary for allowance in a telephonic or personal interview.

To the extent necessary, Applicant petitions for an extension of time under 37 CFR §1.136. The Commissioner is authorized to charge any deficiency in fees, including extension of time fees, or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 25 December 2009

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